

WE CLAIM:

1. A hydraulic pressure intensifier apparatus, comprising:
a hydraulic pressure intensifier defining a circuit for hydraulic fluid having
5 an intensifier inlet for receiving hydraulic fluid at a first pressure and an intensifier outlet
for selectively delivering hydraulic pressure at either the first hydraulic pressure or a
second pressure higher than the first hydraulic pressure; and
a vacuum powered actuator for selectively controlling the hydraulic
pressure intensifier to provide hydraulic fluid at the intensifier outlet at the first or the
10 second hydraulic pressure.
2. The hydraulic pressure intensifier apparatus of claim 1, further comprising
a vacuum circuit therein, completely separated from the circuit for hydraulic fluid
- 15 3. The hydraulic pressure intensifier apparatus of claim 1 further comprising
a mechanically actuated outlet valve apparatus for allowing a flow of hydraulic fluid
between the intensifier inlet and the intensifier outlet when the vacuum powered actuator
is controlling the intensifier to provide hydraulic fluid to the intensifier outlet at the first
pressure, and for blocking a flow of hydraulic fluid between the intensifier inlet and outlet
20 when the vacuum powered actuator is controlling the intensifier to provide hydraulic fluid
to the intensifier outlet at the second pressure.
4. The hydraulic pressure intensifier apparatus of claim 3 wherein the outlet
valve apparatus further allows a flow of hydraulic fluid from the intensifier inlet and
25 intensifier outlet when the pressure at the intensifier outlet is less than the pressure at the
intensifier inlet while the vacuum powered actuator is controlling the intensifier to
provide hydraulic fluid to the intensifier outlet at the second pressure.

5. The hydraulic pressure intensifier apparatus of claim 1 including a latching annunciation element for detecting when the vacuum powered actuator is controlling the hydraulic pressure intensifier for supplying fluid at the second pressure.

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6. The hydraulic pressure intensifier apparatus of claim 1 wherein the hydraulic pressure intensifier includes an intensifier movable wall having a larger surface thereof connectable in fluid communication with the intensifier inlet and a smaller surface thereof connected in fluid communication with the intensifier outlet.

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7. The hydraulic pressure intensifier apparatus of claim 6, further comprising:

an intensifier internal fluid bypass passage providing fluid communication between the intensifier inlet and the smaller surface of the intensifier movable wall; and

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an intensifier inlet valve operatively actuated by the vacuum powered actuator for selectively directing hydraulic fluid from the intensifier inlet to either the larger surface of the intensifier movable wall, or alternatively through the intensifier internal bypass passage to the smaller surface of the intensifier movable wall.

8. The hydraulic pressure intensifier apparatus of claim 1, comprising:
a housing defining the intensifier inlet and outlet, and a stepped intensifier cylinder bore having a larger end and a smaller end, with the intensifier inlet connected in fluid communication with the larger end of the intensifier cylinder bore and the intensifier outlet connected in fluid communication with the smaller end of the intensifier cylinder bore, the housing further defining an intensifier internal fluid bypass passage providing fluid communication between the intensifier inlet and the smaller end of the intensifier cylinder bore; and
an intensifier inlet valve operatively actuated by the vacuum powered actuator for selectively directing hydraulic fluid from the intensifier inlet to either the larger end of the intensifier cylinder bore, or through the intensifier internal bypass passage to the smaller end of the intensifier cylinder bore.
9. The hydraulic pressure intensifier apparatus of claim 8, further comprising:
an intensifier piston having a larger and a smaller end thereof, the larger end thereof disposed within and slidingly sealed to the larger end of the intensifier cylinder bore, and the smaller end thereof disposed within and slidingly sealed to the smaller end of the cylinder bore; and
an intensifier piston return spring disposed between the piston and the housing for urging the piston to move within the intensifier cylinder bore toward the larger end of the intensifier cylinder bore.
10. The hydraulic pressure intensifier apparatus of claim 9 further comprising a mechanically actuated outlet valve apparatus for allowing a flow of hydraulic fluid between the intensifier inlet and the intensifier outlet when the vacuum powered actuator is controlling the intensifier to provide hydraulic fluid to the intensifier outlet at the first pressure, and for blocking a flow of hydraulic fluid between the intensifier inlet and outlet when the vacuum powered actuator is controlling the intensifier to provide hydraulic fluid to the intensifier outlet at the second pressure.

11. The hydraulic pressure intensifier apparatus of claim 10 wherein the outlet valve apparatus further allows a flow of hydraulic fluid between the intensifier inlet and intensifier outlet when the pressure at the intensifier outlet is less than the pressure at the intensifier inlet while the vacuum powered actuator is controlling the intensifier to
5 provide hydraulic fluid to the intensifier outlet at the second pressure.

12. The hydraulic pressure intensifier apparatus of claim 10, wherein:
the intensifier piston return spring urges the piston toward a first position in the intensifier cylinder bore when the vacuum powered actuator is controlling the
10 hydraulic pressure intensifier to provide hydraulic fluid at the intensifier outlet at the first hydraulic pressure;

the mechanically actuated outlet valve apparatus includes a poppet that is open to allow fluid flow through the outlet valve apparatus when the intensifier piston is in the first position, and is closed by contact with the small end of the intensifier piston
15 when the piston has moved a predetermined distance from the first position of the intensifier piston toward the small end of the cylinder bore;

the smaller end of the intensifier piston defines a bore therein operatively connected to provide a sealed fluid connection with the intensifier inlet, such that all fluid flow between the inlet and outlet of the intensifier must flow through the bore in the
20 intensifier piston;

the poppet closes the bore in the intensifier piston when the poppet is in contact with the smaller end of the intensifier piston;

the outlet valve apparatus includes a poppet spring operatively connected between the poppet and the housing for urging the poppet toward contact with the smaller
25 end of the intensifier piston; and

the poppet spring is compressible for allowing the poppet to move away from the smaller end of the intensifier piston when the pressure at the intensifier outlet is less than the pressure at the intensifier inlet, to thereby allow a flow of hydraulic fluid through the bore in the intensifier piston from the intensifier inlet to intensifier outlet
30 while the vacuum powered actuator is controlling the intensifier to provide hydraulic fluid to the intensifier outlet at the second pressure.

13. The hydraulic pressure intensifier apparatus of claim 10, wherein:
the intensifier piston return spring urges the piston toward a first position
in the intensifier cylinder bore when the vacuum powered actuator is controlling the
5 hydraulic pressure intensifier to provide hydraulic fluid at the intensifier outlet at the first
hydraulic pressure;
the intensifier internal bypass passage extends completely past the
intensifier piston and includes a first bypass port located adjacent the intensifier outlet for
providing fluid communication between the internal bypass passage and the smaller end
10 of the intensifier cylinder bore;
the intensifier internal bypass passage also includes a second bypass port
providing fluid communication between the bypass passage and the smaller end of the
intensifier cylinder bore at a point spaced a predetermined distance away from the
smaller end of the intensifier piston, toward the intensifier outlet, when the intensifier
15 piston return spring is holding the intensifier piston in the first position;
the intensifier piston includes a seal affixed thereto for blocking the
second bypass port when the intensifier piston has moved the predetermined distance
toward the intensifier outlet; and
the mechanically operated outlet valve apparatus further comprises a
20 spring operated check/relief valve disposed in the bypass passage between the first and
second bypass ports for blocking flow from entering the bypass passage through the first
bypass port, so long as the pressure at the first bypass port is greater than the pressure at
the second bypass port, and for allowing flow through the bypass passage and the first
bypass port from the intensifier inlet to the intensifier outlet if the pressure at the second
25 bypass port exceeds the pressure at the first bypass port.

14. The hydraulic pressure intensifier apparatus of claim 7, wherein:
the intensifier inlet valve includes a valve seat, a movable valve element of ferromagnetic material configured for mating with the valve seat; and
5 the vacuum powered actuator includes a movable actuator element thereof including a magnet for lifting the movable valve element off of the valve seat when the movable actuator element is positioned in close proximity to the movable valve element of the intensifier inlet valve.
- 10 15. The hydraulic pressure intensifier apparatus of claim 14, further comprising a retaining device for urging the movable valve element to remain mated with the valve seat when the movable actuator valve element is moved out of close proximity to the movable valve element of the intensifier inlet valve.
- 15 16. The hydraulic pressure intensifier apparatus of claim 14, wherein:
the housing further defines a vacuum cylinder bore of the vacuum powered actuator having a vacuum connection port at one end thereof and a vent to atmospheric pressure at an opposite end thereof;
the movable actuator element is an actuator piston disposed within and
20 slidingly sealed to the vacuum cylinder bore between the vacuum port and the vent to thereby separate the vacuum cylinder bore into a vacuum chamber in fluid communication with the vacuum port, and a vented chamber in fluid communication with the vent.
- 25 17. The hydraulic pressure intensifier apparatus of claim 16, wherein the vacuum cylinder bore and the intensifier inlet valve are separated from one another by an imperforate wall of non-magnetic material.

18. The hydraulic pressure intensifier apparatus of claim 16 wherein:
the hydraulic pressure intensifier further includes an actuator spring
element for urging the actuator piston to move toward the vented cavity of the actuator
cylinder bore and into close proximity to the movable valve element;
the movable valve element of the intensifier inlet valve is mated with the
valve seat and blocks fluid flow between the intensifier inlet and the large end of the
intensifier cylinder bore when a vacuum applied to the vacuum port moves the actuator
piston out of close proximity to the movable valve element; and
the movable valve element is lifted off of the valve seat to allow fluid flow
through the intensifier internal fluid bypass passage between the intensifier inlet and the
smaller end of the intensifier cylinder bore when vacuum is removed from the vacuum
port and the actuator piston is in close proximity to the movable valve element.
15. 19. A brake apparatus comprising:
a braking device,
a master cylinder for supplying pressurized fluid at a master cylinder
pressure to the braking device in response to an input force applied to the master cylinder;
a vacuum booster operatively connected to the master cylinder for
augmenting the input force applied to the master cylinder to increase the master cylinder
pressure supplied by the master cylinder in response to the input force; and
a hydraulic pressure intensifier apparatus, including a hydraulic pressure
intensifier and a vacuum powered actuator;
the hydraulic pressure intensifier defining a circuit for hydraulic fluid
having an intensifier inlet for receiving hydraulic fluid from the master cylinder at the
master cylinder pressure and an intensifier outlet for selectively delivering hydraulic
pressure to the braking device at either the master cylinder pressure or at an intensified
pressure higher than the master cylinder pressure, and
the vacuum powered actuator selectively controlling the hydraulic pressure
intensifier to provide hydraulic fluid at the intensifier outlet at the master cylinder
pressure or the intensified hydraulic pressure.

20. The brake apparatus of claim 19 including a latching annunciation element for detecting when the vacuum powered actuator is controlling the hydraulic pressure intensifier for supplying fluid at the intensified pressure.

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21. The brake apparatus of claim 19, wherein:
the vacuum powered actuator controls the hydraulic pressure intensifier to deliver fluid to the braking device at the master cylinder pressure when a vacuum is present at the vacuum booster; and

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the vacuum powered actuator controls the hydraulic pressure intensifier to deliver fluid to the braking device at the intensified pressure when a vacuum is not present at the vacuum booster.

22. The brake apparatus of claim 21, wherein the hydraulic pressure intensifier of claim further includes a mechanically actuated outlet valve apparatus for allowing a flow of hydraulic fluid between the intensifier inlet and the intensifier outlet when the vacuum powered actuator is controlling the intensifier to provide hydraulic fluid to the intensifier outlet at the master cylinder pressure, and to block a flow of hydraulic fluid between the intensifier inlet and outlet when the vacuum powered actuator is controlling the intensifier to provide hydraulic fluid to the intensifier outlet at the intensified pressure.

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23. The brake apparatus of claim 22 wherein the mechanically actuated outlet valve apparatus further allows a flow of hydraulic fluid between the intensifier inlet and intensifier outlet when the pressure at the intensifier outlet is less than the pressure at the intensifier inlet while the vacuum powered actuator is controlling the intensifier to provide hydraulic fluid to the intensifier outlet at the second pressure.

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24. A method for operating a brake apparatus including a braking device, a master cylinder for supplying pressurized fluid at a master cylinder pressure to the braking device in response to an input force applied to the master cylinder, and a vacuum booster operatively connected to the master cylinder for augmenting the input force applied to the master cylinder to increase the master cylinder pressure supplied by the master cylinder in response to the input force, the method comprising:

providing a hydraulic pressure intensifier defining a circuit for hydraulic fluid having an intensifier inlet for receiving hydraulic fluid from the master cylinder at the master cylinder pressure and an intensifier outlet for selectively delivering hydraulic pressure to the braking device at either the master cylinder pressure or at an intensified pressure higher than the master cylinder pressure, and

selectively controlling the hydraulic pressure intensifier with a vacuum powered actuator to provide hydraulic fluid at the intensifier outlet at the master cylinder pressure or at the intensified hydraulic pressure.

25. The method of claim 24 further comprising allowing a flow of hydraulic fluid between the intensifier inlet and intensifier outlet when the pressure at the intensifier outlet is less than the pressure at the intensifier inlet while the vacuum powered actuator is controlling the intensifier to provide hydraulic fluid to the intensifier outlet at the intensified hydraulic pressure.